WBS: 1.2 6
QA: N/A

Civilian Radioactive Waste Management System
Management and Operating Contractor

Title III Evaluation Report for the Subsurface Lighting System

BABFAC000-01717-5705-00001 REV 00

September 8, 1998

Prepared for:

U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 30307
North Las Vegas, Nevada 89036-0307

Prepared by:

TRW Environmental Safety Systems Inc.
1261 Town Center Drive
Las Vegas, Nevada 89134

Under Contract Number
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Prepared by:

Leslie Fernandez
Leslie J. Fernandez, Technical Document Preparer

9/8/98
Date:

Approved by:

William R. Kennedy, Department Manager

9/14/98
Date.

Checked by:

William J. Reed
William J. Reed, Checker

9/9/98
Date:

TITLE III EVALUATION REPORT
Subsurface Lighting System
(BABFAC000)

1. OBJECTIVE

1.1 Introduction

This Title III Evaluation Report (TER) provides the results of an evaluation that was conducted on the Subsurface Lighting System. This TER has been written in accordance with the Technical Document Preparation Plan for the Mined Geologic Disposal System Title III Evaluation Reports (BA0000000-01717-4600-00005 REV 03).

This TER replaces in its entirety TER same title, DI #.BA0000000-01717-5705-00005 Rev 00.

1.2 Objective

The objective of this evaluation is to provide recommendations to ensure consistency between the technical baseline requirements, baseline design, and the as-constructed Subsurface Lighting System. Recommendations for resolving discrepancies between the as-constructed system, and the technical baseline requirements are included in this report. Cost and Schedule estimates are provided for all recommended modifications.

This report does not address items which do not meet current safety or code requirements. These items are identified to the CMO and immediate action is taken to correct the situation. The report does identify safety and code items for which the A/E is recommending improvements . The recommended improvements will exceed the minimum requirements of applicable code and safety guide lines. These recommendations are intended to improve and enhance the operation and maintenance of the facility.

1.3 Methodology

The methodology used in the Title III Evaluation Reports of the Subsurface Lighting System consists of the following activities:

- a field investigation to inspect the as-constructed system;
- comparison of the as-constructed system with the Exploratory Studies Facility Design Requirements (ESFDR) to determine if the as-constructed system satisfies the requirements;
- a review of design Level 3 design documents, design analyses, field investigation data, and as-constructed documentation to deviations between the design and as-constructed Subsurface Lighting System .

- a review of operational requirements to determine if the as-constructed system is capable of performing/supporting the operational requirements; and

- development of recommendations to resolve discrepancies.

2. SCOPE

This TER covers the Subsurface Lighting System which is considered a temporary system. The Subsurface Lighting System includes the systems, subsystems, and components that provide illumination for ESF subsurface operation to include portal entrances, ramps, support and test alcoves, test drifts, underground shop areas, testing equipment, the subsurface muck conveyor system, and the main tunnel. The Subsurface Lighting System also includes the pole mounted lights outside of the portal entrances. Therefore, the ESFDR document requirements for surface will be applied to the pole mounted lights.

The subsurface lighting system interfaces with the subsurface power system: CI BABFAA000.

This TER does not cover the ECRB Cross-Drift lighting System.

3. QUALITY ASSURANCE

The purpose of this TER is not to implement QA controls associated with the Subsurface Lighting System. Rather, this document identifies those QA controls which continue to be applicable to the operation of the system. The implementation of QA control is specifically addressed in the design drawings and specifications for the Subsurface Lighting System.

This evaluation does not comprise a QA design input. The Systems, Structures, and Components to which it applies are not classified in accordance with QAP-2-3, *Classification of Permanent Items*, and do not rely on or incorporate any QA controls identified within any applicable Determination of Importance Evaluation (DIE). Preparation of this evaluation is not subject to *Quality Assurance Requirements and Description* (QARD) requirements. QA: N/A.

4. FIELD INSPECTION

4.1 Summary: Field inspections were conducted by walking down the as-constructed lighting system. The inspections were conducted visually and with the aid of a light meter for determining footcandle levels. Lighting fixture mounting methods were also inspected. Horizontal distances were determined using the tunnel stationing markers located on the wall of the main tunnel.

4.2 Date: April 15, 1997, April 22, 1997 and June 25, 1998

4.3 Participants: Participants in the field walkdowns were:

Joan Smith	Test Facility Design Department
Bill Reed	Test Facility Design Department
Jorge Calle	Test Facility Design Department
Leslie Fernandez	Test Facility Design Department
Gary Teraoka	Systems Engineering and Integration

4.4 Records Reviewed: Keiwit/PB working drawings commonly called As-Constructed Drawings.

ELABSK-001, Electrical (Underground) Working Drawing 1 of 8
ELABSK-002, Electrical (Underground) Working Drawing 2 of 8
ELABSK-003, Electrical (Underground) Working Drawing 3 of 8
ELABSK-004, Electrical (Underground) Working Drawing 4 of 8
ELABSK-005, Electrical (Underground) Working Drawing 5 of 8
ELABSK-006, Electrical (Underground) Working Drawing 6 of 8
ELABSK-007, Electrical (Surface) Working Drawing 7 of 8
ELABSK-008, Electrical (Surface) Working Drawing 8 of 8
Tunaba.dwg, ESF-TS North Ramp Utilities As-Built STA 0+00 to 5+00
Tunabc.dwg, ESF-TS North Ramp Utilities As-Built STA 5+00 to 10+00
Tunabd.dwg, ESF-TS North Ramp Utilities As Built STA 10+00 to 15+00
Tunabg.dwg, ESF-TS North Ramp Utilities As-Built STA 15+00 to 20+00
Tunabh.dwg, ESF-TS North Ramp Utilities As-Built STA 20+00 to 25+00
Tunabi.dwg, ESF-TS North Ramp Utilities As-Built STA 25+00 to 30+00
Tunabk.dwg, ESF-TS North Ramp Utilities As-Built STA 30+00 to 35+00
Tunabl.dwg, ESF-TS North Ramp Utilities As-Built STA 35+00 to 40+00
Tunabn.dwg, ESF-TS North Ramp Utilities As-Built STA 40+00 to 45+00
Tunabo.dwg, ESF-TS North Ramp Utilities As-Built STA 45+00 to 50+00
Tunabb.dwg, ESF-TS North Ramp Utilities As-Built STA Alcove #1-Alcove #2
Tunabf.dwg, ESF-TS North Ramp Utilities As-Built STA Alcove #3-Alcove #4
Tunabj.dwg, ESF-TS North Ramp Utilities As-Built STA Alcove #5
Tunabm.dwg, ESF-TS North Ramp Utilities As-Built STA Alcove #6

4.5 Results:

4.5.1 The main tunnel area has been constructed in accordance with the A/E design. The main tunnel area primarily consist of UL listed tunnel metal halide light fixtures with weatherproof enclosures. The main drift Illumination levels within the threshold and interior zones of the main 7.62 m tunnel met or exceeded minimum requirements. Light meter readings averaged 20 footcandles.

In the alcoves and niches, portable light fixtures (either incandescent or fluorescent) are used. These lighting fixtures were installed and designed by the constructor. The portable light fixtures are UL listed for indoor/outdoor

operations with watertight plug connections. Alcove lighting levels, except for Alcove #5, were below 5 footcandles (See Attachment VI - Lighting Survey). Additionally, the Yucca Mountain Project requires underground personnel to wear cap lamps or carry flashlights . The cap lamps supplement the existing lights thereby providing task lighting so that subsurface personnel can do their work safely and efficiently. If the task requires a lighting level greater than that existing with present alcove lights and cap lamps, then portable lights can be used to increase the lighting level. After completion of this work, the portable lights can be moved to another location if needed or removed to restore the alcove to its original condition.

4.5.2 Voltage drop calculations were done to determine if voltage drop is a problem. (See Attachments I, II, III and IV.) No voltage drop problems were found.

4.5.3 No exit or emergency lighting with battery backup exists within the tunnel or alcoves/niches.

5. OPERATIONAL REQUIREMENTS

5.1 System Description:

The main tunnel lighting has been constructed in accordance to the A/E design. The main tunnel area primarily consist of UL listed tunnel metal halide light fixtures with weatherproof enclosures which are left in operation twenty-four hours a day.

In the alcoves and niches portable light fixtures are used which was installed and designed by the constructor. The portable light fixtures are UL listed for indoor/outdoor operations with watertight plug connections. Alcove lighting levels except for Alcove #5 were below 5 footcandles (See Attachment VI - Lighting Survey). Except in Alcove #2, the alcoves and Niches Lighting Systems are left in operation twenty-four hours a day.

Additionally, the Yucca Mountain Project requires underground personnel to wear cap lamps or carry flashlights. The cap lamps/flashlight supplement the existing lights thereby providing task lighting so that subsurface personnel can do their work safely and efficiently. If the task requires a lighting level greater than that existing with present lights and cap lamps/flashlight, then portable lights are installed.

Finally, the Subsurface Fire Hazards Analysis calls for exit and emergency lighting (Ref. 9.4).

5.2 Operating Parameters:

Table 5.2-1 Operational Requirements: Operating Parameters

Operating Parameters	Reference	Discussion
OSHA 29 CFR 1926.800 (*l*) (1) (Ref 9.10) shall be a minimum of 5 footcandles for Tunnel and underground work area.	DOE Technical Direction Dated Apr 02, 1998 (Ref. 9.16)	Illumination in the main 7.62 m tunnel areas meets or exceeds the minimum of 5 footcandles.

5.3 Operating Permits: There are no operating permits that effect the Subsurface Lighting System.

5.4 Operating ES&H:

Table 5.4-1 Operational Requirements: Operating ES&H

Operating Parameters	Reference	Discussion
Exit signs, with lighting, shall be provided at intersections in the subsurface areas.	BABFAH000-01717-0200-00121 REV 01 (Ref. 9.4)	This requirement has not been met. Currently no exit signs exist in the subsurface facilities.
Emergency lighting with battery backup shall be installed at telephone station located at 180m intervals to illuminate the telephone and fire extinguisher during an emergency.	BABFAH000-01717-0200-00121 REV 01 (Ref. 9.4)	This requirement has not been met. No provisions have been made for emergency lighting with battery backup in the subsurface facilities.

5.5 Operating QA Controls: The Subsurface Lighting System is not governed by any QA controls and the QA classification is "N/A".

6. BASELINE REQUIREMENTS

6.1 ESFDR Requirements

Table 6.1-1 ESFDR Requirements

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied ?**	**Description**
3.2.1.2.1.1.A (Surface) The ESF surface facilities and equipment shall be designed with features that minimize the growth of fungus, bacteria, and algae.	N/A	**Requirement does not apply.** The environmental conditions at this desert location do not require consideration of these features in the design of the Subsurface Lighting System.
3.2.1.2.1.1.B (Surface) Earthquake design parameters for surface facilities shall be calculated in accordance with the information in Appendix A.	No	The only part of the Subsurface Lighting System that this requirement applies to is the North and South Portal Lights. The North Portal lights are seismically mounted on the box cut walls with rock bolts. The South Portal light system is a portable and temporary lighting system. It consists of flood light fixtures on short steel poles inserted into drilled holes into the rock surface with no anchoring means or seismic bracing. The ESFDR requirement should be revised. The lighting system is not considered a life safety system (Ref 9.21). Therefore, the lighting system components should not require expensive and time-consuming shaker tests demonstrating that this equipment can withstand a seismic event. The seismic requirement for lighting systems and its components should only address the mounting of lighting equipment so that this equipment will not fall down and hurt someone during a seismic event. Additionally, design directives changed the seismic zone from "3" to "2B". **Recommendations:** **1. The temporary lights at the South Portal should be replaced with a more permanent system with seismic bracing.** **2. Revise the ESFDR to change the seismic zone from "3" to "2B" and delete "withstand" requirement for lighting system.**

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied ?**	**Description**
3.2.1.2.1.1.C (Surface) The ESF surface facilities shall be designed to withstand 75 mph (high winds) prevailing winds with maximum gusts up to 97 mph.	No	The only part of the Subsurface Lighting System that this requirement applies to is the North and South Portal Lights. The North Portal lights can withstand 75 mph (high winds) prevailing winds with maximum gusts up to 97 mph because they are mounted on the Box Cut walls with 4 to 8 ft rock bolts. However, the South Portal light system is a portable and temporary lighting system. It consists of flood light fixtures on short steel poles inserted into drilled holes into the rock surface with no anchoring means. **Recommendation: The temporary lights at the South Portal should be replaced with a more permanent system with wind bracing.**
3.2.1.2.1.1.D (Surface) The ESF surface facilities and equipment shall be designed with appropriate grounding to withstand and minimize the potential for damage due to a direct lightning strike.	Yes	The only place where the subsurface lighting system is exposed to lightning strikes is at the portal entrances. The exposed portal lighting systems are protected by the North and South Portal Lightning Protection Systems. Additionally, all lighting circuits are grounded and bonded in accordance with the NEC requirements.
3.2.1.2.1.1.E (Surface) The ESF surface facilities and equipment shall be designed to withstand maximum daily precipitation levels of 2.18 inches within a 24 hour period.	Yes	The Subsurface Lighting System equipment that is located on the ESF surface is designed for exterior installation and therefore is designed to withstand the maximum daily precipitation levels specified in this requirement.
3.2.1.2.1.1.F (Surface) The ESF surface facilities and equipment shall be designed to withstand and operate in temp. ranging from a low of -14 deg.F to a high of 108 deg.F.	Yes	Equipment is designed for exterior installation and therefore is designed to withstand and operate in the temperature range.

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied ?**	**Description**
3.2.1.2.1.1.G (Surface) The ESF surface facilities and equipment shall be designed to withstand max. loads caused by snowfall of 10 in. max. in a 24 hr. period.	Yes	The equipment that is part of the Subsurface Lighting System that is on the ESF surface as well as the mounting methods used, were designed for exterior installation and therefore were designed to withstand maximum loads caused by the snowfall specified in this requirement.
3.2.1.2.1.1.H (Surface) The ESF surface facilities and equipment shall be designed to withstand and operate in a relative humidity environment of 13 to 71%.	Yes	Equipment is designed for exterior installation and therefore is designed to withstand the relative humidity ranges specified in this requirement.
3.2.1.2.1.1.I (Surface) The ESF surface facilities and equipment shall be designed to withstand the loads caused by a 100 yr. probable max. flood local storm identified in Reference Information Base, YMP/93-02. (Ref. 9.20)	N/A	Portals are located outside the maximum flood area.
3.2.1.2.1.1.J (Surface) The ESF surface facilities and equipment shall be designed to withstand and operate in an environment with sand and dust.	Yes	The As-constructed equipment installed at the portals is suitable to withstand and operate in an environment of sand and dust.

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied ?**	**Description**
3.2.1.2.1.2.A (Subsurface) The permanent and temporary items of the ESF shall be designed to withstand the applicable seismic environment specified in Appendix A.	No	The lighting system in the main tunnel has been designed and installed with seismic bracing. Portable lights in the alcoves do not depict a seismic hazard. However, the South Portal lighting needs seismic bracing. The ESFDR requirement should be revised. The lighting system is not considered a life safety system (Ref 9.21). Therefore, the lighting system components should not require expensive and time-consuming shaker tests demonstrating that this equipment can withstand a seismic event. The seismic requirement for lighting systems and its components should only address the mounting of lighting equipment so that this equipment will not fall down and hurt someone during a seismic event. Additionally, design directives changed the seismic zone from "3" to "2B". **Recommendation:** **1. The temporary lights at the South Portal should be replaced with a more permanent system with seismic bracing.** **2. Revise ESFDR to remove the "withstand" seismic requirement and replace with similar wording used for the East-West Drift Temporary/Construction Support Utilities: "Mounting of utilities shall consider seismic loading specified in Appendix A of the ESFDR Document, YMP/CM-0019, Revision 2."** **3. Revise the ESFDR to change the seismic zone from "3" to "2B".**
3.2.1.2.1.2.B (Subsurface) The ESF subsurface facilities and equipment shall be designed to withstand and operate in a dusty environment.	Yes	The main tunnel lights has been constructed in accordance to the A/E design. Lighting in the main tunnel area primarily consist of UL listed tunnel metal halide light fixtures with weatherproof enclosures. In the alcoves and niches portable light fixtures are used which was installed and designed by the constructor. The portable light fixtures are UL listed for indoor/outdoor operations with watertight plug connections. These fixtures can operate in a dusty environment.

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied ?**	**Description**
3.2.1.2.1.2.C (Subsurface) The ESF subsurface facilities and equipment shall be designed to withstand and operate in temperatures ranging from a low of 50 degrees F to a high of 70 degrees F.	Yes	The main tunnel lights has been constructed in accordance to the A/E design. Lighting in the main tunnel area primarily consist of UL listed tunnel metal halide light fixtures with typical operating temperature range of -29 °C to 55 °C (-20 °F to 131 °F). In the alcoves and niches portable light fixtures are used which was installed and designed by the constructor. The portable light fixtures are UL listed for indoor/outdoor operations with a typical operating temperature range of -29 °C to 40 °C (-20 °F to 104 °F).
3.2.1.2.1.2.D (Subsurface) The ESF subsurface facilities and equipment shall be designed to withstand and operate in a relative humidity environment of 13% to 71%.	Yes	The main tunnel lights has been constructed in accordance to the A/E design. Lighting in the main tunnel area primarily consist of UL listed tunnel metal halide light fixtures with weatherproof enclosures. In the alcoves and niches portable light fixtures are used which was installed and designed by the constructor The portable light fixtures are UL listed for indoor/outdoor operations with watertight plug connections. These fixtures can operate from no humidity to pouring rain.
3.2.1.2.2.A (General) The ESF non-permanent items shall be designed for a 25 year maintainable service life.	Yes	The Subsurface Lighting System in the ESF is non-permanent. All the equipment is readily accessible and maintainable for the 25 year service life required.
3.2.1.2.2.B (General) The ESF permanent items shall be designed for a 150 year maintainable service life.	N/A	**Requirement does not apply.** This requirement does not pertain to the Subsurface Lighting System because this system is considered non-permanent.

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied ?**	**Description**
3.2.1.2.3 (General) ESF constraints 3.2.1.2.3.A, 3.2.1.2.3.B, 3.2.1.2.3.C, 3.2.1.2.3.D, 3.2.1.2.3.E, 3.2.1.2.3.F, 3.2.1.2.3.G, 3.2.1.2.3.H, 3.2.1.2.3.I	Yes	The as-constructed Subsurface Lighting System satisfies these requirements. The constructor installed and operates the Subsurface Lighting System in accordance with the Subsurface General Construction Specification, Document BAB000000-01717-6300-01501 Rev 04 (Ref. 9.2.2) and Temporary Surface Construction Facilities Specification, Document BAB000000-01717-6300-01500 Rev 01 (Ref. 9.2.1). Both specifications list the applicable ESFDR requirements for constructor compliance for temporary construction and operation.
3.2.1.2.4.A (General) The ESF shall be designed in compliance with the applicable requirements contained in Uniform Building Code.	N/A	**Requirement does not apply.** In regard to the Subsurface Lighting System, this requirement is not applicable. The Uniform Building Code refers to buildings, not underground lighting installations and pole mounted lights.
3.2.1.2.4.B (General) The ESF shall be designed in compliance with the applicable requirements contained in ACI 318 Building Code Requirements for reinforced concrete.	N/A	**Requirement does not apply.** The design of the Subsurface Lighting System is not affected by the requirements contained in ACI 318 Building Code Requirements for reinforced concrete.
3.2.1.2.4.C (General) The ESF shall be designed in compliance with the applicable requirements contained in DOE Order 6430.1A	N/A	DOE Technical Direction Dated Apr 02, 1998 deleted the requirements for compliance to DOE order 6430.1A. Additionally, DOE ordered 6430.1A was never written for tunnels or tunnel construction. **Recommendation: Delete DOE order 6430.1A compliance from the ESFDR.**

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied ?**	**Description**
3.2.1.2.4.D (General) The ESF shall be designed in compliance with the applicable requirements contained in DOE Order 5480.7A	N/A	**The requirement does not apply.** YMP/90-37 (Ref 9.17), Safety and Health Plan, directs the M&O to use DOE order 420.1 (Ref. 9.18) which canceled 5480.7A as applicable to the Yucca Mountain project. The Subsurface Fire Hazard Analysis lists applicable requirements of DOE order 420.1 for subsurface design. **Recommendation: Change ESFDR requirement from DOE order 5480.7A to DOE order 420.1.**
3.8.1.2.C (Subsurface) The service facilities and equipment required for maintaining underground services shall be provided to support ESF operation and in situ site characterization.	Yes	The Subsurface Lighting System is provided to support ESF operation and in situ characterization and it appears that the Lighting System is being adequately maintained. Additionally, the subsurface lighting systems are suitable to support subsurface maintenance activities.
3.8.2.1.2.A (Subsurface) The underground utilities for the ESF shall not preclude monitoring and investigation of in situ testing.	Yes	The Subsurface Lighting System is provided to support ESF operation and in situ characterization and does not preclude these activities.
3.8.2.1.2.B (Subsurface) Subsurface utility systems, when installed, shall not restrict foot, vehicular, or shaft and ramp conveyance traffic.	Yes	The Subsurface Lighting System is located along the walls of the main tunnel and the top surface of the alcoves and does not impede traffic of any kind.
3.8.2.1.2.C (Subsurface) Subsurface utility systems, when installed, shall not obstruct ventilation.	Yes	The Subsurface Lighting System is located along the walls of the main tunnel and the top surface of the alcoves and is clear of ventilation ducts. This system does not obstruct ventilation.

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied ?**	**Description**
3.8.2.1.2.D (Subsurface) To the extent practical, underground utility systems and associated furnishings (hangars, brackets, etc.) shall be removed following final use.	Yes	All components of the Subsurface Lighting System are readily accessible and may be disassembled and removed following final use.
3.8.2.1.2.E (Subsurface) The distribution of utilities shall support flexibility in the siting of the final testing locations.	Yes	The distribution of utilities for the Subsurface Lighting System does support flexibility in the siting of the final testing locations. All components of the Subsurface Lighting System are readily accessible and may be disassembled and removed following final use.
3.8.2.1.2.F (Subsurface) Subsurface utilities requiring remote monitoring and control shall provide the necessary equipment to interface with the subsurface monitoring and control system and the IDCS.	N/A	**Requirement does not apply.** The Subsurface Lighting System does not require remote monitoring and control, or the ability to interface with the subsurface monitoring and control system at this time.

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied ?**	**Description**
3.8.2.1.2.G (Subsurface) Subsurface utilities shall support the testing utility requirements in Appendix B.	Yes	The lighting in the test alcoves does meet the minimum requirements set forth in Appendix B. In the alcoves and niches portable light fixtures are used which was installed by the constructor. The portable light fixtures are UL listed for indoor/outdoor operations with watertight plug connections. Additionally, the Yucca Mountain Project requires underground personnel to wear cap lamps or carry flashlights. The cap lamps/flashlights supplement the existing lights thereby providing task lighting so that subsurface personnel can do their work safely and efficiently. If the task requires a lighting level greater than that existing with present alcove lights and cap lamps/flashlights (e.g. Alcoves #3 and #5), then portable lights can be used to bring the lighting level up to acceptable and safe level.
3.8.2.4.1.A (Subsurface) Lighting shall be provided at each testing area and alcove, refuge chamber, and at the shaft and ramp station areas.	Yes	Lighting is provided at each test area to include test alcoves, niches, and tunnels. Currently there are no refuge chambers or shaft and ramp station areas.
3.8.2.4.1.B (Subsurface) Temporary lighting shall be provided for special needs such as mapping, photography and work lights near instrumentation junction boxes.	Yes	On field inspections it was noted that temporary lighting was provided for special applications as needed.
3.8.2.4.1.C (Subsurface) Exit lighting with battery backup shall be provided to identify direction of evacuation to refuge chambers and/or shaft and ramp stations.	No	No exit lighting with battery backup exists at this time. If in an emergency, personnel within the tunnel become disoriented, they may be unable to locate the most expedient evacuation route. At this time in the tunnel there are no refuge chambers or shaft and ramp stations. **Recommend: add exit lighting with battery backup to identify the direction of evacuation as determined by the Subsurface Fire Hazard Analysis (Ref. 9.4).**

ESFDR REQUIREMENTS		
ESFDR Requirement	**Satisfied ?**	**Description**
3.8.2.4.1.D (Subsurface) Emergency lighting with battery backup that is charged continuously by facility power, and actuates automatically, shall be provided in each shop, testing areas, refuge chamber, and shaft and ramp station areas.	No	No emergency lighting with battery backup exists at this time. However, Per 29 CFR 1926.800 (g)(4), each employee shall have an acceptable portable hand lamp or cap lamp in his or her work area for emergency use. In addition, it is still recommended that emergency lighting with battery backup be added at locations of telephones, fire extinguishers and first aid stations. **Recommendation: Add emergency lighting with battery backup at critical locations within the tunnel as determined by the Subsurface Fire Hazards Analysis (Ref. 9.4).**
3.8.2.4.1.E (Subsurface) The lighting provided in each testing area shall be based on specific test requirements for that area.	Yes	On field inspections it was noted that Alcoves #2 and #5 were provided with special design lighting and Alcove #1, #3, #4, #6 & #7 portable lights where installed to meet specific test requirements needs.
3.8.2.4.1.G (Subsurface) The Subsurface Lighting System shall have a minimum availability of 99.49%.	Yes	The Subsurface Lighting System does have a minimum availability of 99.49%. Refer to Design Input Request dated August 4, 1997 (Ref. 9.19). However, the lighting system is not a system important to life safety (Ref. 9.21); therefore is not critical for the lighting system to meet any availability figure. **Recommendation: Delete the ESFDR requirement for minimum availability for ESF lighting system.**

6.2 As-Constructed Deviations and Recommendations

The main tunnel area has been constructed in accordance to the A/E design. The main tunnel area primarily consist of UL listed tunnel metal halide light fixtures with weatherproof enclosures. The main drift Illumination levels within the threshold and interior zones of the main 7.62 m tunnel met or exceeded minimum requirements. Light meter readings averaged 20 footcandles.

In the alcoves and niches portable light fixtures are used which was installed and designed by the constructor. The portable light fixtures are UL listed for indoor/outdoor operations with watertight plug connections. Alcove lighting levels except for Alcove #5 were below 5 footcandles (See Attached Lighting Survey).

Additionally, the Yucca Mountain Project requires underground personnel to wear cap lamps or carry flashlights. The cap lamps/flashlight supplement the existing lights thereby providing task lighting so that subsurface personnel can do their work safely and efficiently. If the task requires a lighting level greater than that existing with present alcove lights and cap lamps/flashlights, then portable lights can be used to bring the lighting level up to acceptable and safe level. After completion of this work, the portable lights can be moved to another location if needed or removed to restore the alcove to its original condition.

Table 6.2-1 As-Constructed Deviations and Recommendations

As-Constructed Deviations and Recommendations		
As-Constructed Deviations	**Design Documents**	**Recommendations**
Alcoves and niches lighting was not constructed in accordance with A/E design drawings.	BABF00000-01717-2100-44016 thru 44026 (Ref 9.1.8 thru 9.1.18)	The alcoves/niches lighting is adequate to support test activities. The M&O drawing for alcoves/niches lighting should be replaced with construction phase O&M drawings.
Exit lighting with battery backup was not installed.	BABF00000-01717-2100-44016 thru 44026 (Ref 9.1.8 thru 9.1.18)	Add exit lighting with battery backup to identify direction of evacuation as determined by the Subsurface Fire Hazard Analysis (Ref. 9.4).
Emergency lighting with battery backup was not installed.	BABF00000-01717-2100-44016 thru 44026 (Ref 9.1.8 thru 9.1.18)	It is recommended that emergency lighting with battery backup be added as determined by the Subsurface Fire Hazard Analysis (Ref. 9.4).

7. SUMMARY OF RECOMMENDATIONS

7.1 Construction & Engineering:

7.1.1 Add exit lighting with battery backup at intersections to identify the direction of evacuation within the tunnel and alcoves as required by the Subsurface Fire Hazard Analysis (Ref. 9.4) .

7.1.2 Add emergency lighting with battery backup as required by the Subsurface Fire

Hazard Analysis at 167 m (600 feet) intervals to light stations with telephone and fire extinguisher (Ref. 9.4).

7.1.3 The temporary lights at the South Portal should be replaced with a permanent lighting system with seismic and wind bracing similar to the North Portal Lighting.

7.2 ESFDR:

7.2.1 Change the ESFDR to reflect current DOE directive to implement OSHA 29 CFR 1926 for ESF design in place of DOE order 6430.1A (Ref. 9.19).

7.2.2 Revise ESFDR to remove the "withstand" seismic requirement and replace with similar wording used for the East-West Drift Temporary/Construction Support Utilities: "Mounting of utilities shall consider seismic loading specified in Appendix A of the ESFDR Document, YMP/CM-0019, Revision 2."

7.2.3 Revise the ESFDR to change the seismic zone from "3" to "2B".

7.2.4 Delete the ESFDR requirement for minimum availability for ESF lighting system.

7.2.5 Change ESFDR requirement from DOE order 5480.7A to DOE order 420.1.

8. COST AND SCHEDULE ESTIMATES

Summary of the cost estimate is listed below. See Attachment V for a detail breakout. The ESFDR hours is covered by the revision of the ESFDR.

8.1 Construction Cost

8.1.1 Add Exit Lights to Existing Light System: $4,123
8.1.2 Add Emergency Lights @ Critical Locations : $33,974
8.1.3 South Portal Lighting: $17,720
8.1.4 Total Construction Cost: $55,817

8.2 Engineering Effort:

8.2.1 Add Exit Lights to Existing Light System: $6,000
8.2.2 Add Emergency Lights @ Critical Locations : $12,000
8.2.3 South Portal Lighting: $24,000
8.2.4 Total Engineering Cost: $42,000

9. REFERENCES

9.1 M&O Drawings

9.1.1	BABFA0000-01717-2100-44042 Rev 01,	Subsurface Electrical Standard Details Sht 3
9.1.2	BABFA0000-01717-2100-44043 Rev 01,	Subsurface Electrical Standard Details Sht 4
9.1.3	BABF00000-01717-2100-44044 Rev 01,	Subsurface Electrical Standard Details Sht 5
9.1.4	BABF00000-01717-2100-44045 Rev 01,	Subsurface Electrical Standard Details Sht 6
9.1.5	BABFA0000-01717-2100-44047 Rev 01,	Subsurface Electrical Sections and Details Sht 2
9.1.6	BABFA0000-01717-2100-44048 Rev 01,	Subsurface Electrical Sections and Details Sht 3
9.1.7	BABF00000-01717-2100-44213 Rev 00,	Subsurface Power, Lighting, Grounding Notes, Legend & References
9.1.8	BABF00000-01717-2100-44016 Rev 01,	North Portal 0000 Power Lighting Grounding Plan & Detail
9.1.9	BABF00000-01717-2100-44017 Rev 01,	TS North Ramp 0000-0300 Power Lighting Grounding Plan & Detail
9.1.10	BABF00000-01717-2100-44018 Rev 01,	TS North Ramp 0300-0600 Power Lighting Grounding Plan & Detail
9.1.11	BABF00000-01717-2100-44019 Rev 01,	TS North Ramp 0600-0900 Power Lighting Grounding Plan & Detail
9.1.12	BABF00000-01717-2100-44020 Rev 01,	TS North Ramp 0900-1200 Power Lighting Grounding Plan & Detail
9.1.13	BABF00000-01717-2100-44021 Rev 01,	TS North Ramp 1200-1500 Power Lighting Grounding Plan & Detail
9.1.14	BABF00000-01717-2100-44022 Rev 01,	TS North Ramp 1500-1800 Power Lighting Grounding Plan & Detail
9.1.15	BABF00000-01717-2100-44023 Rev 01,	TS North Ramp 1800-2100 Power Lighting Grounding Plan & Detail
9.1.16	BABF00000-01717-2100-44024 Rev 01,	TS North Ramp 2100-2400 Power Lighting Grounding Plan & Detail
9.1.17	BABF00000-01717-2100-44025 Rev 01,	TS North Ramp 2400-2700 Power Lighting Grounding Plan & Detail
9.1.18	BABF00000-01717-2100-44026 Rev 01,	TS North Ramp 2700-3000

Power Lighting Grounding Plan & Detail

9.2 M&O Specifications

9.2.1 BAB000000-01717-6300-01500 Rev. 01, Temporary Surface Construction Facilities

9.2.2 BAB000000-01717-6300-01501 Rev. 05, Subsurface General Construction

9.2.3 BAB000000-01717-6300-16501 Rev. 01, Lamps

9.2.4 BAB000000-01717-6300-16502 Rev. 01, Fixture Accessories

9.2.5 BAB000000-01717-6300-16050 Rev. 03, Basic Electrical Materials and Methods

9.2.6 BAB000000-01717-6300-16510 Rev. 01, Fluorescent Lights

9.2.7 BABBDA000-01717-6300-16512 Rev. 01, High Intensity Discharge Lights

9.2.8 BAB000000-01717-6300-16535 Rev. 02, Emergency Lights

9.3 Keiwit/PB working drawings commonly called As-Constructed Drawings.

9.3.1 ELABSK-001: Electrical (Underground) Working Drawing 1 of 8
9.3.2 ELABSK-002: Electrical (Underground) Working Drawing 2 of 8
9.3.3 ELABSK-003: Electrical (Underground) Working Drawing 3 of 8
9.3.4 ELABSK-004: Electrical (Underground) Working Drawing 4 of 8
9.3.5 ELABSK-005: Electrical (Underground) Working Drawing 5 of 8
9.3.6 ELABSK-006: Electrical (Underground) Working Drawing 6 of 8
9.3.7 ELABSK-007: Electrical (Surface) Working Drawing 7 of 8
9.3.8 ELABSK-008: Electrical (Surface) Working Drawing 8 of 8
9.3.9 Tunaba.dwg: ESF-TS North Ramp Utilities As-Built STA 0+00 to 5+00
9.3.10 Tunabc.dwg: ESF-TS North Ramp Utilities As-Built STA 5+00 to 10+00
9.3.11 Tunabd.dwg: ESF-TS North Ramp Utilities As Built STA 10+00 to 15+00
9.3.12 Tunabg.dwg: ESF-TS North Ramp Utilities As-Built STA 15+00 to 20+00
9.3.13 Tunabh.dwg: ESF-TS North Ramp Utilities As-Built STA 20+00 to 25+00
9.3.14 Tunabi.dwg: ESF-TS North Ramp Utilities As-Built STA 25+00 to 30+00
9.3.15 Tunabk.dwg: ESF-TS North Ramp Utilities As-Built STA 30+00 to 35+00
9.3.16 Tunabl.dwg: ESF-TS North Ramp Utilities As-Built STA 35+00 to 40+00
9.3.17 Tunabn.dwg: ESF-TS North Ramp Utilities As-Built STA 40+00 to 45+00
9.3.18 Tunabo.dwg: ESF-TS North Ramp Utilities As-Built STA 45+00 to 50+00
9.3.19 Tunabb.dwg: ESF-TS North Ramp Utilities As-Built STA Alcove #1-Alcove #2
9.3.20 Tunabf.dwg: ESF-TS North Ramp Utilities As-Built STA Alcove #3-Alcove #4

9.3.21 Tunabj.dwg: ESF-TS North Ramp Utilities As-Built STA Alcove #5

9.3.22 Tunabm.dwg: ESF-TS North Ramp Utilities As-Built STA Alcove #6

9.4 Subsurface Fire Hazards Analysis, BABFAH000-01717-0200-00121 Rev 01

9.5 Illuminating Engineering Society of North America Lighting Handbook, 1987 Application Volume

9.6 Illuminating Engineering Society of North America Lighting Handbook, 1984 Reference Volume

9.7 NFPA 70, 1996 Edition, National Electrical Code

9.8 NFPA 110, 1996 Edition, Standard for Emergency and Standby Power Systems

9.9 29 CFR 1910, Occupational Safety & Health Standards

9.10 29 CFR 1926, Safety & Health Regulations for Construction

9.11 IEEE/ANSI C2, 1997 Edition, National Electric Safety Code

9.12 DOE Order 6430.1A, General Design Criteria

9.13 YMP/CM-0019, Exploratory Studies Facility Design Requirements

9.14 YMP/CM-0021, Site Design & Test Requirements Document

9.15 YMP/93-02, Reference Information Base

9.16 D.O.E. Letter, Subject: Technical Direction - Exploratory Study Facility Site Characterization Design and Installation Base Code Compliance, Dated April 2, 1998

9.17 YMP/90-37, Safety and Health Plan

9.18 DOE Order 420.1, Facility Safety

9.19 CRWMS/M&O 1997 Design Input Transmittal, Item #2 Subsurface Lighting System, From James Robertson to Leslie Fernandez, Date 8/12/87

9.20 YMP/93-02, Reference Information Base

9.21 TRW Interoffice Correspondence, Subject: ESF Life Safety Systems-Seismic Event System Safety Evaluation, From D. Dwyn Dated July 7, 1998

10. ATTACHMENTS

I. Voltage Drop Calculation - TP-1A (Station 00+00) to Station 5+36
II. Voltage Drop Calculation - MPC#2 (Station 17+70) to Station 23+00
III. Voltage Drop Calculation - MPC#4 (Station 34+85) to Station 41+00
IV. Voltage Drop Calculation - Station 41+00 to MPC#5 (Station 47+00)
V. Subsurface Lighting System Cost Estimate
VI. Alcoves Lighting Survey

VOLTAGE DROP CALCULATIONS

SUBSURFACE LIGHTING SYSTEM
TP-1A (Sta 00+00) to Sta 5+36

WO : 3969

THREE PHASE POWER

4 WIRE ALTERNATING CURRENT VOLTAGE DROP CALCULATION

COPPER WIRE SIZE :	8
TOTAL LENGTH :	1660
LENGTH BETWEEN LOADS :	150
OPERATING VOLTAGE PHASE TO PHASE :	480
OPERATING VOLTAGE PHASE TO NEUTRAL :	277
AMPERES PER DEVICE :	1.100
OHMS PER 1000' OF CABLE :	0.7780
CIRCULAR MILL OF CABLE :	16510

CABLE LENGTH	NUMBER OF DEVICES	AMPS TOTAL AT DROP	LINE TO LINE VOLTS DROP PER LENGTH	
10	12	13.20	0.178	
150	11	12.10	2.452	
150	10	11.00	2.229	
150	9	9.90	2.006	
150	8	8.80	1.783	
150	7	7.70	1.560	
150	6	6.60	1.337	
150	5	5.50	1.114	
150	4	4.40	0.891	
150	3	3.30	0.669	
150	2	2.20	0.446	
150	1	1.10	0.223	

1660	CALCULATED CABLE LENGTH

TOTAL VOLTAGE DROP TO LAST DEVICE	14.89	
PERCENT VOLTAGE DROP OVER LENGTH	3.10%	

NOTES :

The number of fixtures on this circuit has been estimated.

VOLTAGE DROP CALCULATIONS

SUBSURFACE LIGHTING SYSTEM
MPC#2 (Sta 17+70) to Sta 23+00

W.O.: 3969

THREE PHASE POWER

4 WIRE ALTERNATING CURRENT
VOLTAGE DROP CALCULATION

COPPER WIRE SIZE:	8
TOTAL LENGTH:	1660
LENGTH BETWEEN LOADS:	150
OPERATING VOLTAGE PHASE TO PHASE:	480
OPERATING VOLTAGE PHASE TO NEUTRAL:	277
AMPERES PER DEVICE:	1.100
OHMS PER 1000' OF CABLE:	0.7780
CIRCULAR MIL OF CABLE:	16510

CABLE LENGTH	NUMBER OF DEVICES	AMPS TOTAL AT DROP	LINE TO LINE VOLTS DROP PER LENGTH
10	12	13.20	0.178
150	11	12.10	2.452
150	10	11.00	2.229
150	9	9.90	2.006
150	8	8.80	1.783
150	7	7.70	1.560
150	6	6.60	1.337
150	5	5.50	1.114
150	4	4.40	0.891
150	3	3.30	0.669
150	2	2.20	0.446
150	1	1.10	0.223

1660	CALCULATED CABLE LENGTH

TOTAL VOLTAGE DROP TO LAST DEVICE	14.89
PERCENT VOLTAGE DROP OVER LENGTH	3.10%

NOTES:

The number of fixtures on this circuit has been estimated.

VOLTAGE DROP CALCULATIONS

SUBSURFACE LIGHTING SYSTEM
MPC#4 (Sta 34+85) to Sta 41+00

w o.: 3969

THREE PHASE POWER

4 WIRE ALTERNATING CURRENT
VOLTAGE DROP CALCULATION

COPPER WIRE SIZE :	8
TOTAL LENGTH :	1850
LENGTH BETWEEN LOADS :	150
OPERATING VOLTAGE PHASE TO PHASE :	480
OPERATING VOLTAGE PHASE TO NEUTRAL :	277
AMPERES PER DEVICE :	1.100
OHMS PER 1000' OF CABLE :	0.7780
CIRCULAR MILL OF CABLE :	16510

CABLE LENGTH	NUMBER OF DEVICES	AMPS TOTAL AT DROP	LINE TO LINE VOLTS DROP PER LENGTH	
50	13	14.30	0.966	
150	12	13.20	2.674	
150	11	12.10	2.452	
150	10	11.00	2.229	
150	9	9.90	2.006	
150	8	8.80	1.783	
150	7	7.70	1.560	
150	6	6.60	1.337	
150	5	5.50	1.114	
150	4	4.40	0.891	
150	3	3.30	0.669	
150	2	2.20	0.446	
150	1	1.10	0.223	
1850	CALCULATED CABLE LENGTH			

TOTAL VOLTAGE DROP TO LAST DEVICE	18.35
PERCENT VOLTAGE DROP OVER LENGTH	3.82%

NOTES :

The number of fixtures on this circuit has been estimated.

VOLTAGE DROP CALCULATIONS

SUBSURFACE LIGHTING SYSTEM
Sta 41+00 to MPC#5 (Sta 47+00)

W.O.: 3969

THREE PHASE POWER
4 WIRE ALTERNATING CURRENT
VOLTAGE DROP CALCULATION

COPPER WIRE SIZE :	8
TOTAL LENGTH :	1850
LENGTH BETWEEN LOADS :	150
OPERATING VOLTAGE PHASE TO PHASE :	480
OPERATING VOLTAGE PHASE TO NEUTRAL :	277
AMPERES PER DEVICE :	1.100
OHMS PER 1000' OF CABLE :	0.7780
CIRCULAR MILL OF CABLE :	16510

CABLE LENGTH	NUMBER OF DEVICES	AMPS TOTAL AT DROP	LINE TO LINE VOLTS DROP PER LENGTH	
50	13	14.30	0.966	
150	12	13.20	2.674	
150	11	12.10	2.452	
150	10	11.00	2.229	
150	9	9.90	2.006	
150	8	8.80	1.783	
150	7	7.70	1.560	
150	6	6.60	1.337	
150	5	5.50	1.114	
150	4	4.40	0.891	
150	3	3.30	0.669	
150	2	2.20	0.446	
150	1	1.10	0.223	
1850	CALCULATED CABLE LENGTH			

TOTAL VOLTAGE DROP TO LAST DEVICE	18.35
PERCENT VOLTAGE DROP OVER LENGTH	3.82%

NOTES :

The number of fixtures on this circuit has been estimated.

ATTACHMENT V

SUBSURFACE LIGHTING SYSTEM COST ESTIMATE

SUBSURFACE LIGHTING SYSTEM COST ESTIMATE CONSTRUCTION

ADD EXIT LIGHTS TO EXISTING LIGHT SYSTEM

				MATERIAL COST:		LABOR COST:			
ITEM #	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	Manhours	UNIT COST	SUBTOTAL	TOTAL
1	Exit Lights	14	EA	$139 00	$1,946 00	0 5	$50 00	$350 00	$2,296 00
2	2 " of Cable	28	FT	$4 40	$123 20	0 2	$50 00	$280 00	$403 20
3	2 Cable Terminations	28	EA	$9 60	$268 80	0 2	$50 00	$280 00	$548 80
4	Loco Operators					3 5	$50 00	$175 00	$175 00
5	Supports	14	EA	$25 00	$350 00	0 5	$50 00	$350 00	$700 00
6	Electrical Foreman					2 52	$55 00	$138 60	$138 60
	(@ 10% electrical labor)								
SUBTOTAL					$2,688 00			$1,435 00	$4,123 00

ADD EMERGENCY LIGHTS @ CRITICAL LOCATIONS

				MATERIAL COST:		LABOR COST:			
ITEM #	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	Manhours	UNIT COST	SUBTOTAL	TOTAL
1	Emergency Lights	43	EA	$258 00	$11,094 00	0 5	$50 00	$1,075 00	$12,169 00
2	20' of Cable	860	FT	$4 40	$3,784 00	0 2	$50 00	$8,600 00	$12,384 00
3	2 Cable Terminations	86	EA	$9 60	$825 60	0 2	$50 00	$860 00	$1,685 60
4	Loco Operators					30	$50 00	$1,500 00	$1,500 00
5	Supports	43	EA	$45 00	$1,935 00	2	$50 00	$4,300 00	$6,235 00
6	Electrical Foreman					29 7	$55 00	$1,631 85	$1,631 85
	(@ 10% electrical labor)								
SUBTOTAL					$17,638 60			$16,335 00	$33,973 60

SOUTH PORTAL AREA LIGHTING

				MATERIAL COST:		LABOR COST:			
ITEM #	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	Manhours	UNIT COST	SUBTOTAL	TOTAL
1	ADD HID FIXTURES	4	EA	$430 00	$1,720 00	8	$50 00	$1,800 00	$3,320 00
2	Cable #8 Type W	400	FT	$4 40	$1,760 00	0 25	$50 00	$5,000 00	$6,760 00
3	Supports	4	EA	$200 00	$800 00	32	$50 00	$5,400 00	$7,200 00
4	Electrical Foreman					8	$55 00	$440 00	$440 00
SUBTOTAL					$4,280 00			$13,440 00	$17,720 00

TOTAL COST

				MATERIAL COST:		LABOR COST:			
ITEM #	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	Manhours	UNIT COST	SUBTOTAL	TOTAL
TOTAL					$24,606 60			$31,210 00	$55,816 60

ATTACHMENT V

SUBSURFACE LIGHTING SYSTEM COST ESTIMATE

SUBSURFACE LIGHTING SYSTEM COST ESTIMATE
ENGINEERING EFFORT

ADD EXIT LIGHTS TO EXISTING LIGHT SYSTEM

				MATERIAL COST		LABOR COST			
ITEM #	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	Manhours	UNIT COST	SUBTOTAL	TOTAL
1	Design Work Dwgs	1	EA			80	$75 00	$6 000 00	$6,000 00
SUBTOTAL					$0 00			$6,000 00	$6,000 00

ADD EMERGENCY LIGHTS @ CRITICAL LOCATIONS

				MATERIAL COST:		LABOR COST:			
ITEM #	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	Manhours	UNIT COST	SUBTOTAL	TOTAL
1	Design Work Dwgs	2	EA			80	$75 00	$12,000 00	$12,000 00
SUBTOTAL					$0 00			$12,000 00	$12,000 00

SOUTH PORTAL AREA LIGHTING

				MATERIAL COST.		LABOR COST:			
ITEM #	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	Manhours	UNIT COST	SUBTOTAL	TOTAL
1	Design Work Analysis	1	EA			160	$75 00	$12,000 00	$12,000 00
2	Design Work Dwgs	2	EA			80	$75 00	$12,000 00	$12,000 00
SUBTOTAL					$0 00			$24,000 00	$24,000 00

TOTAL COST

				MATERIAL COST		LABOR COST.			
ITEM #	DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL	Manhours	UNIT COST	SUBTOTAL	TOTAL
TOTAL					$0 00			$42,000 00	$42,000 00

ATTACHMENT VI
ALCOVES LIGHT SURVEY

Date Accomplished: June 25 1998

Accomplished By: Leslie Fernandez
Staff Electrical Engineer
M&O/MK, Test Facility Design Dept
(702) 295-4288

Agustin Passalacqua
Staff Engineer
M&O/MK, Title III Design
(702) 295-4288

Measurement Meter: The Watt Stopper Illiminometer FX-200

Alcove #1:

Location	Foot-Candle Reading	Average Reading in Foot-Candle
Entrance	2.2	
O+27	2.3	
O+47	1.9	
O+67	1.1	
Bulkhead	0.3	
		1.56

Alcove #2:

Location	Foot-Candle Reading	Average Reading in Foot-Candle
O+08	3.8	
O+13	4.2	
O+18	4.5	
O+25	3.8	
O+30	3.2	
O+37	1.8	
O+48	3.3	
		3.51

ATTACHMENT VI
ALCOVES LIGHT SURVEY

Alcove #3:

Location	Foot-Candle Reading	Average Reading in Foot-Candle
Entrance	3.1	
O+08	2.2	
O+18	1.5	
O+21	2.2	
O+25	1.5	
O+32	1.0	
Face	0.4	
		1.70

Alcove #4:

Location	Foot-Candle Reading	Average Reading in Foot-Candle
Entrance	0.8	
O+8	2.0	
O+16	5.8	
O+26	2.6	
O+31	1.0	
O+38	1.5	
O+42	1.3	
O+44	2.2	
Face	3.3	
		2.46

ATTACHMENT VI
ALCOVES LIGHT SURVEY

Alcove #5:

Location	Foot-Candle Reading	Average Reading in Foot-Candle
Entrance	0.8	
O+13	2.7	
O+21	2.7	
O+28	0.4	
O+37	1.9	
O+42	1.1	
O+50	0.5	
O+65	0.5	
O+60	5.3	
O+70	6.6	
O+89	6.8	
O1+OO	6.9	
O1+25	1.6	
O1+65	3.3	
O1+80	5.3	
TURN	10.3	
DAS Niche	7.0	
Vestibule	70.0	
TCO Office Niche O+04	3.0	
TCO Office Niche O+08	1.9	
TCO Office Niche O+16	3.5	

TCO Office Niche Turn 0+07	2.6	
TCO Office Niche Face 0+07	1.8	
		6.37

Alcove #6:

Location	Foot-Candle Reading	Average Reading in Foot-Candle
Entrance	4.6	
O+ 20	0.6	
O+30	4.6	
O+42	5.3	
O+50	3.3	
O+ 60	0.3	
O+64	5.0	
O+70	2.8	
O+74	2.1	
O+84	1.3	
O+98	7.6	
O1 +06	3.3	
O1 +14	2.2	
O1 +22	5.6	
O1 +34	2.8	
O1 +38	3.5	
O1 +42	0.5	
O1 +50	2.2	

O1+58	2.1	
O1+64	3.9	
O1+70 CORNER	2.0	
O +08	1.0	
O +13	1.8	
End	2.2	
		2.94

Alcove #7:

Location	Foot-Candle Reading	Average Reading in Foot-Candle
Entrance	1.4	
O+5	3.2	
O+16	0.9	
O+30	1.7	
O+35	0.6	
O+40	1.1	
O+50	4.1	
O+60	3.9	
		2.1